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Analysis and Assessment of Military and Non-Military Impacts on Biodiversity: A Framework for Environmental Management on DoD Lands Using the California Mojave Desert as a Regional Case Study

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Summary

This interim report describes activities accomplished on behalf of the investigation "Analysis and Assessment of Military and Non-Military Impacts on Biodiversity: A Framework for Environmental Management on DoD Lands Using the California Mojave Desert as a Case Study" during FY97 by the U.S. Environmental Protection Agency (EPA) along with its research collaborators. This project is being conducted under the aegis of the DoD Strategic Environmental Research and Development Program (SERDP). The principal accomplishments of the project during FY97 centered on the development of a comprehensive research and project design, the establishment of the project organization and management structure, and substantive progress on a number of research tasks. These accomplishments are summarized in the following principal activities and are reported: a peer-reviewed research plan, satellite image processing, biodiversity prioritization and species richness, and airborne videography for habitat discrimination.

RESEARCH PLAN

A research plan was developed to conform with EPA research design and was both internally (within EPA) and externally peer-reviewed. The plan was completed during the fiscal year and printed and accepted by EPA following revisions in December, 1997. The comprehensive research plan is an official EPA document and is written as a formal research design to describe the elements which are to be accomplished within the scope of the project.

Synopsis of Research Plan

The U.S. Environmental Protection Agency has initiated a program: "Analysis and Assessment of Military and Non-Military Impacts on Biodiversity: A Framework for Environmental Management on DoD Lands within the California Mojave Desert". The Research Plan describes research which will be carried out by investigators

from EPA as well as the U.S. Forest Service, the National Research Council, and others, in conjunction with the U.S. Department of Defense (DoD) Strategic Environmental Research and Development Program (SERDP). The project is in the formative stages of a four-year research effort that will require extensive interaction and coordination with a number of investigators, as well as land managers and other stakeholders within the California Mojave Desert.

The purpose of the research is to evaluate the effects of human activities (non-military as well as military) on biodiversity and related environmental concerns within the Mojave Desert ecoregion of California both at the present and in the year 2020. The research addresses several major questions:

- What is the current status of the Mojave Desert landscape relative to its ability to sustain biodiversity, in particular native terrestrial vertebrates?

- How has the landscape been altered by human activities? Which stressors have had significant impact on biodiversity and related environmental concerns?

- How might the landscape be altered (by the year 2020)? What will be the concomitant effects of a number of land use scenarios on biodiversity and related environmental concerns?

These research questions are restated into six specific research objectives:

1) Identify the features of the landscape (habitat type and other configurations) that are essential for the long-term sustainability of native plant and animal communities in the Mojave Desert.

2) Develop methods to characterize these "biologically relevant" landscape features using remote sensing, and assess the accuracy and precision of these landscape assessments.

3) Evaluate how human activities have altered the Mojave landscape; in particular, define relationships bewteen specific types of human activities and changes in landscape features that affect biodiversity.

4) Develop and evaluate approaches for predicting the effects of landscape change (and human activities) on biodiversity and on the viability of species of special concern (e.g., the desert tortoise) that can be applied over large spatial and temporal scales.

5) Apply this information and analytical techniques to assess the ecological consequences of alternative land use scenarios being considered for the Mojave.

6) Develop a framework and user-friendly interface that will facilitate the use and further applications of our data and analytical techniques by decision makers in the region.

In addition to introductory and background information, the plan describes the major components of the research and its organizational structure, budget and schedule. The background section (2.0) provides information on the natural history and human activities of the California portion of the Mojave Desert and on related research projects.

The Landscape Status and Change section (3.0) describes the approach for characterizing the present landscape and how the landscape has, in the past, and may, in the future, be altered by human activities. The landscape will be described primarily in terms of its vegetation, terrain, and land use. Part of this descriptive information will provide the input for subsequent habitat assessment, evaluation, and classification. In addition, analytical and modeling tools for describing and evaluating Alternative Future Scenarios will be developed. The landscape section also includes an evaluation of the present landscape in terms of the causes of ecosystem degradation.

Section 4.0 (Biodiversity Response) describes the objectives and approach for assessing biodiversity responses to landscape change. Biodiversity response is being viewed at multiple scales. These include a landscape response as a surrogate for biodiversity, single key species (the desert tortoise, Gopherus agassizi), 12-15 focal vertebrate species, and total vertebrate species. The section describes the approach which will be taken to assess and evaluate these responses and implications which future landscape changes will have on distribution and populations of these species and groups of species.

Section 5.0 (Integration and Alternative Future Scenarios) describes how research on biodiversity response and landscape change will be integrated with stakeholder concerns to assess the effects of alternative land use strategies on biodiversity and related environmental concerns. Both the development as well as the evaluation of alternative futures will be emphasized. It is essential that the results and analytical techniques developed are understood and transferable to decision makers in the Mojave Desert region.

The research plan also presents the research management structure, a budget, expected outputs and a schedule.

SATELLITE IMAGE PROCESSING

Satellite imagery has been purchased for the CA Mojave Desert. The imagery spans a twenty year time period and is being used for change analysis based on disturbance and surface degradation.

The following table outlines the type of imagery, dates, resolution, and coverage extent for each set of images acquired.

Table 1. Landsat imagery acquired for the California Mojave Desert. Full Landsat Thematic Mapper (TM) coverage of the entire California Mojave Desert was acquired for the years 1993 and 1996 at the 28.5 m spatial resolution. Landsat MultiSpectral Scanner (MSS) scenes for each of the decades 197x, 198x, and 199x varies in date within the full Mojave desert coverage.

Platform and Sensor	Date of Acquisition	Spatial Resolution	†Spectral Resolution	Number of Bands	Covera Exten
Landsat TM	August 1996	28.5 m	RGB, NIR, MIR	7	full Mojav
Landsat TM	June 1994	28.5 m	RGB, NIR, MIR	7	subse
Landsat TM	July/Aug 1993	28.5 m	RGB, NIR, MIR	7	full Mojav
Landsat TM	June 1984	28.5 m	RGB, NIR, MIR	7	subse
Landsat MSS	1973	79 m	RG, NIR	4	full Mojav
Landsat MSS	1986	79 m	RG, NIR	4	full Mojav
Landsat MSS	1991	79 m	RG, NIR	4	full Mojav

† RGB = visible red, green, blue; NIR = near infra-red; MIR = mid infrared

Image Processing.

Initial processing of the Landsat data includes histogram matching of different dates within the same year and georeferencing to ground control points or image to image rectification. Atmospheric or terrain corrections may be warranted following further investigation.

Several different change analysis methods will be conducted and field verified. Field verification will determine which results are most accurate. Spectral transformations of the imagery for change analysis will include but not be limited to albedo, tasselled cap transformation, and principal component analysis. Investigations into the utility of indices of biogenic soil fauna will also be conducted and should these indices prove reliable and accurate, they will also be used for change analysis.

At the Mojave-wide level, the change analysis will the basis for identification of areas which have proven to be particularly susceptible to stresses on and around the desert. Patterns at the regional level such as road (on and off-road) density, surface soil alteration, and vegetation change will be assessed based on results from this analysis. Within areas of greatest disturbance and change, hypotheses relating to desertification, degradation and disturbance will be generated for further investigation at a finer level.

VIDEOGRAPHY FOR HABITAT ASSESSMENT

An important objective of the overall investigation is to devise a method for assessing habitat. Typically, habitat is assessed directly via vegetation with terrain features used to differentiate microhabitat features. In the Mojave, vegetation is not readily disciminable via aerial and satellite techniques. As such, other physical features of the landscape will be used as habitat indicators. Such features include geomorphology, lithography, soils, and microterrain. This approach recognizes that vegetation in the Mojave is sparse to nonexistent and that many, but not all, species are more sensitive to variation in substrate than to variation in vegetation cover or composition. The project is collaborating with a DoD Legacy Vegetation Mapping Project led by the USGS and a Terrain Mapping Program for the Mojave led by the Topographic Engineering Center (YEC) and Louisiana State University. The terrain classes, defined and delineated by interpretation of satellite images, will be instrumental in defining habitat. At finer levels, we are investigating the use of videography to discriminate finer levels of the same features.

We have embarked on a three-phased approach that incorporates airborne videography, model development, and field analysis to address the research objectives and the hypothesis that airborne videography can be used to assess habitat. This approach helps to determine the relationship between physical landscape features and reptilian habitat. This research builds upon research conducted by a number of individuals which combine existing information on reptilian habitat information with information derived from airborne videography to devlop habitat models based upon physical features of the landscape.

Airborne videography was collected over a three day period in the spring of 1997 over study sites in Joshua Tree National Park and the Marine Corps Air Ground Combat Center at 29 Palms (MCAGCC 29 Palms). Coincident with the overflight, ground information on condition of the surface was collected over a series of transects. Initial results show excellent correspondence with the videography signal, ground features sampled and lizard habitat. A research plan was completed during late FY97 for more intensive ground sampling of habitat features and lizard observations. This research will be accomplished during late

spring and summer of FY98. In addition, Landsat and SPOT imagery will be collected over the same area as the videography to assess overall habitat discrimination.

BIODIVERSITY ANALYSIS

Technical Approach:

Include an estimate of the readiness of the science to address the problem. Articulate the scientific tasks and milestones.

This part of the study investigates the spatial relationship and biodiversity of terrestrial vertebrate species in California's Mojave Desert Ecosystem using Gap analysis and other techniques. Gap analysis deals with spatially distributed entities: vegetation cover, species distributions, and land ownership. Comparison of these entities is best facilitated by representing them as geographic information system (GIS) themes. Vegetation classifications and species distribution ranges are mapped as irregularly shaped polygons. In our analysis, individual species' ranges are smoothed to a regular hexagonal grid system. Hexagons are used rather than squares because they possess greater statistical efficiency and are capable of being dynamically more realistic. This smoothing facilitates comparison of different data sets for different species classes.

The science needed to address biodiversity of terrestrial vertebrate species in California's Mojave Desert Ecosystem already exists and has been applied to research efforts in the Pacific Northwest (Kiester et al. 1996, Freemark et al. 1996, Csuti et al. 1997). The major components of this research are species richness, reserve selection or prioritization, sweep analysis and Gap analysis.

Richness--
Species richness analysis is the first stage in the summarization of spatial data for the terrestrial vertebrates, providing a visualization of species diversity for the entire Mojave. Species richness for each hexagon will be calculated by counting the number of different species in each hexagon without regard to area occupied. Areas (hexagons) of relatively high species diversity are highlighted and serve to identify those areas for special management concern. Species richness analysis techniques will be used to identify areas where rare, threatened, and endangered species are most abundant.

Prioritation--
Prioritization analysis involves an algorithmic method of nature reserve selection (Kiester et al. 1996) using an integer programming approach, "maximal location covering problem". IBM's Optimizing Subroutine Library (OSL 2.0 for AIX RISC/6000, IBM Corporation) is used for prioritation computations. The goal is

to determine the minimum number of hexagons that taken together, have an example of every species. This analysis prioritizes areas (hexagons) so that they will have the greatest positive cumulative impact for further research and management of biological diversity. At each stage in determining a prioritization sequence the union of the lists of species for each hexagon is computed to find the list of different species for the combined area. In addition, this prioritization analysis determines the maximum number nth partial coverage by calculating the maximum number of species that could be found in 1, 2, up to n hexagons. For the first partial coverage the hexagon with the most species is selected. Then, all pairs, triplets, and so on are selected to find those that have the greatest combined number of species (Kiester et al 1996). An overall terrestrial vertebrate species richness assessment for the California Mojave Desert has been completed.

Sweeps--

Sweep analysis determines the priority hexagons for one aspect of biodiversity and then calculates how much of any other form of biodiversity is "swept along" by that prioritization. For example, we may determine the four richest hexagons for reptile species and then count the number of mammals that happen to occur in those hexagons. That is, the number of mammal species that are swept by reptiles are counted (Kiester et al 1996). Sweep analysis will continue during FY98.

Gap Analysis

An ARC/INFO GIS coverage of protected areas for the Mojave Desert as defined by the Information Center for the Environment (ICE), University of California, Davis will be used. This cover defines ownership (public, private) of the entire study area. Public lands will be defined as Federal (National Forests, BLM, wilderness, National Monuments, USFWS refuges, National Parks), State of California (State Lands Commission, Department of Forestry and Fire Protection, Department of Parks and Recreation), and county and city regional parks and preserves. Each area will be rated as to its degree of protection or management status from one to four (Scott et al. 1993). The highest degree of protection, Management Status 2, is an area with an active management plan that maintains the land in its natural state (i.e., most national parks, Nature Conservancy preserves, some USFWS National Wildlife Refuges). Management status 2 is an area that is managed for its natural value, but receives use that degrades the quality of the natural communities. Most wilderness areas, refuges managed for recreational use, and BLM Areas of Critical Environmental Concern are included in this classification. Management Status 3 areas are non designated public lands including USFS, BLM, and state park lands that can not be permanently converted to anthropogenic habitat types. The fourth level of protection, Management Status 4, includes private and public land without an existing easement or irrevocable management agreement that maintains native species and habitat, usually urban areas, residential areas and

agriculture lands. Categorization of management status will be determined by reviewing management plans for each ownership type. Areas within areas not usually recognize as meeting management status criteria 1 or 2 such exist. BLM lands, National Forests, or military reserves have such management plans within their jurisdictions. For example desert tortoise preserves and set-a-sides exist on some military reservations. These areas will be identified and included in our analysis. Our focus will on levels one and two for defining protected areas. The last two levels will be considered unprotected with regards to terrestrial vertebrates in the Mojave Desert.

Species distributions, in an ARC/INFO GIS cover, will be overlayed with the coverage of protected areas. The intersection of a species' distribution and protected areas will result in a polygon cover of the species' distribution where each polygon is defined by the degree of protection. Further analysis will determine the quantity of each species' habitat falling into each protection category.

Accomplishments--

1) We defined the Mojave Desert Ecosystem with a Jepson Bioregion boundary for the Mojave Desert.

2) We developed a hexagon coverage of the Mojave Desert from the hexagon grid of the United States, Environmental Protection Agency's Environmental Monitoring and Assessment Program.

3) We have obtained species lists associated with each hexagon in the Mojave from Dr. David M. Stoms, Department of Geography, University of California, Santa Barbara, CA using the California Wildlife Relation System. The California Wildlife Relation System is a database that of species life history attributes and distributions that is fully referenced to allow independent verification of its contents. We have extracted species and associated hexagon identifiers for the Mojave. These hexagon-species data are being used to complete species richness analysis, prioritization, and sweep analysis for the combined terrestrial vertebrates, terrestrial vertebrate class vegetation classes in the Mojave.

4) Developed lists of amphibians, reptiles, birds and mammals occurring in the Mojave Desert from the California Wildlife Relation System, reference literature, and expert consultation.

5) Developed richness maps for all terrestrial vertebrate classes.

6) Prioritized amphibian, reptile, bird and mammalian data identifying critical areas.

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